Department of Energy
Washington, DC 20585

SAFETY EVALUATION REPORT
FOR THE MODEL R-1 BUSS CASK

Docket No. 97-28-9511

SUMMARY

Based on the statements and representations in the Safety Analysis Report for Packaging (SARP), the staff has concluded that the Beneficial Uses Shipping System (BUSS) Cask design meets the requirements of DOE Order 460.1A, 10 CFR Part 71, and 49 CFR Part 173. Compliance with International Atomic Energy Agency (IAEA) Safety Series No. 6 1985 Edition (As Amended 1990) has not been verified, but the review has determined that the SARP demonstrates that the BUSS cask is capable of passing the Normal Conditions of Transport (NCT) and the Hypothetical Accident Conditions (HAC) specified in IAEA Safety Series No. 6 1985 Edition (As Amended 1990). Since the bulk of the SARP remains unchanged when the ownership of the package was transferred from the Albuquerque Operations Office to the Richland Operating Office, this Safety Evaluation Report (SER) references in the various chapters the previous SER, Docket 93-33-9511, April 22, 1994, which in turn refers to evaluations in the original SER, Docket 86-1-9511, February 26, 1991.

REFERENCE

Beneficial Uses Shipping System (BUSS) Cask, Safety Analysis Report for Packaging, Volumes I and II, Report HNF-SD-TP-SARP-024, Revision 0, March 1997, Richland, Washington.

DRAWINGS

The general information and drawings presented in the reference document were reviewed. The review concludes that the description of the packaging is complete and provides an accurate basis for evaluation.

CHAPTER 1 - GENERAL

Chapter 1 of the BUSS SARP, HNF-SD-TP-SAR-024, Revision. 0, March 1997 is identical to the version in the Report SAND 83-0698 (TTC-0430), Revision. 4, May 1993. (The SARP has been reissued by the Richland Operations Office after the ownership of the BUSS cask was transferred from the Albuquerque Operations Office to the Richland Operations Office.) Therefore, SER Docket 93-33-9511 for Chapter 1 is still valid. However, the CoC is to be upgraded to a B(U)-85 designation, indicating that the SARP (HNF-SD-TP-SARP-024) must demonstrate compliance with 10 CFR Part 71 effective April 1, 1996. However HNF-SD-TP-SARP-024 inadvertently states in Section 1.1 of Chapter 1 that it meets the requirements of 10 CFR Part 71 effective January 1, 1993 and 49 CFR Part 173 effective October 1, 1993. This will have to be changed the next time HNF-SD-TP-SARP-024 is revised. There are no requirements in IAEA Safety Series No. 6 1985 Edition (As Amended 1990) that would affect the Chapter 1 of the SER (93-33-9511).

CHAPTER 2 - STRUCTURAL

There were no changes to the BUSS cask hardware since the previous review (SER, Docket 93-33-9511) and approval of the BUSS cask SARP. The technical content of Chapter 2 of the BUSS cask SARP (HNF-SD-TP-SARP-024) has not changed.

Since the previous approval (SER, Docket 93-33-9511), the regulations relevant to the structural requirements have changed only in that the dynamic crush test has been added by 10 CFR 71.73(c)(2) to the list of HAC tests. However, the crush test is required only for packages not exceeding 1,100 lb in weight. The BUSS cask, at over 33,000 lb, exceeds this specified weight. Therefore the crush test need not be addressed.

In addition, recent SARP reviews have addressed the concern that, for the HAC drop to a puncture bar, the bar used in the test must be securely mounted to the unyielding surface. This requirement is automatically satisfied for the BUSS cask evaluation presented in the SARP (HNF-SD-TP-SARP-024) because the puncture test requirement is performed by analysis. In the analytical model the puncture bar is an integral part of the unyielding surface, so the attachment of the puncture bar is not an issue.

Based on the above and on the staff reviews supporting the previous approvals of the BUSS cask, the staff concludes that the BUSS cask structural design has been adequately described and evaluated and that the BUSS cask has adequate structural integrity to meet the requirements of 10 CFR Part 71.

CHAPTER 3 - THERMAL

Since the previous approval (SER, Docket 93-33-9511), the regulations relevant to the thermal requirements have changed only in that the forced convective heat transfer must be included in the thermal evaluation of the package performance under the HAC, specified in 10 CFR 71.73(c)(4). The previous thermal results for the NCT (SER, Docket 93-33-9511) remain valid under the 1996 10 CFR Part 71 regulations. Therefore, only the results for the HAC tests are reviewed here.

3.1 SARP Evaluation

The SARP (HNF-SD-TP-SARP-024) has revised the previous HAC analyses to include the convective heat transfer requirement specified in 10 CFR 71.73(c)(4). A two-dimensional, one-quarter, (r, φ) model of the package was developed and the SINDA/FLUINT finite difference, lumped parameter computer code was used to simulate the HAC thermal event. The convective heat transfer coefficient 20 $W/m^2 \cdot °C$ (3.5 $Btu/h \cdot ft^2 \cdot °F$), appropriate for a flow velocity of 10 m/s (32.8 ft/s), was applied at the package surface. The analyses were performed for a cesium chloride 12-capsule basket. The results of the analyses were then used to determine the effect of convective heat transfer and to modify the results of the previous analyses for the three other basket geometries. HNF-SD-TP-SARP-024 has presented the results for four basket geometries with two fill gases, helium and air, in the cask cavity. The higher temperatures in the air-filled case, where the seals are assumed to fail permitting air to fill the cask cavity, are conservative because the helium is not expected to escape from the cask cavity under accident conditions.

The SINDA/FLUINT computer code, used in simulating the thermal performance of the BUSS cask, was originally developed under NASA sponsorship and has been validated for transportation packages.

3.2 Staff Evaluation

For the HAC thermal event, the staff independent confirmatory analyses used a two-dimensional, radial versus axial, model to represent the geometry of the package. All capsules at the same radial location were combined and modeled as one circular ring. The cesium chloride capsules were modeled as two circular rings, the inner ring representing 4 capsules and the outer ring representing 8 or 12 capsules. The strontium fluoride capsules were modeled as one circular ring to represent 4 or 6 capsules. The radiation environment temperature, for the test period of 30 minutes, was set to 800°C (1475°F) with an emissivity coefficient of 0.9. The forced convective heat transfer of 20 $W/m^2 \cdot °C$ (3.5 $Btu/h \cdot ft^2 \cdot °F$) at the package external surface was applied in the analyses for the test period of 30 minutes. [The IAEA guidelines in Safety Series No. 37, 3rd edition, A-628-20, suggest a convective flow velocity of 5 to 10 m/s (16.4 to 32.8 ft/s) as being appropriate for use during the fire portion of the HAC thermal event. The 20 $W/m^2 \cdot °C$ (3.5 $Btu/h \cdot ft^2 \cdot °F$) heat transfer coefficient at 10 m/s is used because it is conservative.] The analyses were continued beyond the test period of 30 minutes for an 8-hour cool down period. For conservative predictions, the forced convective heat transfer was excluded and the surface emissivity was reduced during the 8-hour cool down period. The analyses were performed for all four basket geometries with air in the cask cavity using the HEATING7 module of the SCALE computer code.

3.3 Package Temperatures

Table 3.1 shows the calculated peak temperatures for the BUSS components during the HAC thermal event with convective heat transfer. Both the SARP

(HNF-SD-TP-SARP-024) and the staff confirmatory results are lower than the maximum allowable temperature limits.

Table 3.1 Summary of Peak Temperatures during HAC Thermal Event

Component	SARP, °C (°F)	Staff, °C (°F)	Allowable, °C (°F)
Strontium Fluoride	765 (1490)	528 (982)	800 (1475)
Cesium Chloride	577 (1070)	478 (892)	800 (1475)
SrF Capsule, Inner Wall	570 (1058)	528 (982)	800 (1475)
CsCl Capsule, Inner Wall	691 (1276)	478 (892)	800 (1475)
Cask Body	289 (562)	182 (359)	592 (1100)
Basket	466 (871	458 (856)	649 (1200)

3.4 Maximum Internal Pressures

Table 3.2 shows the calculated peak pressure for the BUSS cask during the HAC thermal event with convective heat transfer. Both the SARP (HNF-SD-TP-SARP-024) and the staff confirmatory results are lower than the maximum allowable pressure.

Table 3.2 Summary of Peak Pressures during HAC Thermal Event

SARP	Staff	Allowable
270 kPa (39 psia)	318 kPa (46 psia)	446 kPa (64.7 psia)

3.5 Evaluation of Package Performance for HAC Thermal Event

The SARP (HNF-SD-TP-SARP-024) has demonstrated and the staff review has confirmed that the BUSS packaging can provide adequate thermal protection during the HAC thermal event to maintain the containment boundary below the maximum allowable temperature and pressure limits.

3.6 Conclusion

The staff concludes that the thermal features of the BUSS cask have been designed adequately and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 and 49 CFR Part 173 have been met.

CHAPTER 4 - CONTAINMENT

4.1 Methods of Analysis and Confirmation

The confirmatory review covered the adequacy of the source description; the adequacy of the containment boundary description, including design and/or performance specifications for the Special Form capsule claddings and welds; and the supportive information and documentation provided in the Revision 0 of the SARP (HNF-SD-TP-SARP-024).

The contents are Special Form radioactive cesium chloride or strontium fluoride mixtures that are contained in double walled, all welded capsules. After fabrication, the inner capsules were tested to ensure leaktightness in accordance with ANSI N14.5. The outer capsule closure welds were inspected ultrasonically to ensure weld penetration of at least 55% of the wall thickness. The Special Form, double wall capsules provide the containment of radioactive contents for this package.

4.2 NCT and HAC

Revision 0 of the SARP (HNF-SD-TP-SARP-024) has been reviewed to determine that the containment performance of the package complies with requirements of 10 CFR 71.51 under both NCT and HAC. The BUSS cask only provides a confinement boundary for the helium fill gas while the Special Form capsules provide the actual containment. The confinement boundary was judged adequate by the staff for the confinement of helium.

To determine that the Special Form capsules provide adequate containment in packaging, the thermal and stress conditions experienced by the Special Form materials in the packaging must be less severe than the Special Form test conditions of 10 CFR 71.77. The BUSS cask provides external protection for the capsules against high stresses except that during NCT, the capsules will be held at an elevated temperature of 437°C (819°F) for a much longer time than the 10-minute duration specified for the Special Form test at 800°C (1475°F). Exposure of the capsules at 437°C (819°F) for longer times may cause some corrosion of the inner wall of cesium chloride capsules. The estimated corrosion, 0.005 cm (0.002 in) in a 0.24-cm (0.095-in) thick wall for the allowed 30-day transit and wait period, is found to be acceptable.

In addition to the containment provided by the Special Form, double wall capsules, the packaging also confines helium for heat transfer enhancement. Confirmatory analyses of helium leakage have verified that the helium seal design and seal assembly and the leakage testing procedures are adequate for confining helium during the maximum allowable 30-day transit and wait period.

CHAPTER 5 - SHIELDING

Neither the contents, nor the methods of analysis and confirmation have been changed in the Revision. 0 of the SARP (HNF-SD-TP-SARP-024). Consequently the dose rates previously calculated (TRR, Docket 93-33-9511) for NCT and HAC shall continue to meet the 10 CFR Part 71 regulatory requirements.

CHAPTER 6 - CRITICALITY

There is no criticality concern for the BUSS cask because the contents are non-fissile materials.

CHAPTER 7 - OPERATING PROCEDURES

The requirement in the Cask Loading Procedure in the Revision 0 of the SARP (HNF-SD-TP-SARP-024) that the cask cavity be evacuated to 667 Pa (5 torr) for the purpose of verifying the absence of water is acceptable, since 667 Pa (5 torr) is much less than 1,230 kPA (9 torr), the vapor pressure of water at 10°C (50°F), which is the minimum ambient cask cavity temperature allowed during loading.

The operating procedure requirements presented in the SARP (HNF-SD-TP-SARP-024) will result in the safe operation of the BUSS cask when the requirements are incorporated into the user specific procedures, provided quantitative acceptance criteria and repair procedures are specified. Procedures are included which assure that the thermal and radioactive loading of the cask will not exceed design limits, and multiple opportunities are present to detect content overloads. Appropriate radiological protection is assured through the use of radiation surveys during both loading and unloading operations.

Review of the physical condition of the packaging and its critical seal surfaces is required prior to each usage. Post-loading leak tests will assure the integrity of the seals prior to shipment. Closure of the cask lid is done in a straightforward manner, as are the assembly of the impact limiters onto the cask body and the loading of the assembled cask onto the shipping cradle and are considered acceptable.

The confirmatory review found the operating and repair procedures unacceptable because inspections lacked quantitative acceptance criteria and repair procedures. Therefore, the Certificate of Compliance is conditioned to address the preceding deficiencies in the SARP (HNF-SD-TP-SARP-024) with the following requirement:

> "Visual inspections required in Chapters 7 and 8 of the SARP (HNF-SD-TP-SARP-024) shall be conducted to ensure that the packaging is clean and undamaged. Any observed damage such as scratches, dents, cracks, tears, galling, and corrosion shall require detailed inspections, including physical measurements, to verify that the original requirements are satisfied in accordance with the drawings and specifications in the SARP (HNF-SD-TP-SARP-024). If the original requirements are not satisfied, rework or repair shall be done to the original requirements per the drawings and specifications in the SARP (HNF-SD-TP-SARP-024). Any

repair not to the original requirements shall be approved by the Headquarters Certifying Official before being initiated. Category C items [referred to as minor on pages D-3 through D-9 in Vol. II of the SARP (HNF-SD-TP-SARP-024)] are exempt from the preceding additional requirements, as are the packaging seals which are accepted on the basis of leakage rate testing."

The confirmatory review found that the operating procedures in Chapters 7 and 8 with the above requirement are acceptable and in conformance with established guidelines and criteria provided in NRC Regulatory Guide 7.9, and with the regulatory requirements of 10 CFR Part 71, 49 CFR Part 173, and DOE Orders 460.1A and 460.2. The evaluation of the operating procedures with the suggested requirements specified in the Certificate of Compliance provides assurance that under NCT and HAC the transportation of Special Form capsules complies with 10 CFR Part 71.

CHAPTER 8 - ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The Cask Assembly Verification Leakage Test Procedure in the Revision 0 of the SARP (HNF-SD-TP-SARP-024) requires a mass spectrometer leakage test with adequate sensitivity for the lid, and for both the upper and lower port covers. The mass spectrometer leakage test is therefore acceptable. The method of connection of the leakage test equipment has also been reviewed and found acceptable.

Fabrication of the parts of the BUSS cask to the required criteria is assured by numerous inspection tests and material verifications. Forging integrity is verified through magnetic and liquid penetrant inspection, as well as radiographic and/or ultrasonic techniques. Dimensional checks are indicated in a standard, approved manner. Fabrication of the foam-filled impact limiters is verified by weight/volume measurements before and after filling and by testing of a box sample of the foam batch.

To verify the structural design criteria, a hydrostatic pressure test is required before first use that verifies a 150% pressure capability of the cask body and lid. In addition, helium leak tests are required both prior to first use and periodically thereafter.

Shielding integrity is verified before first use by loading the actual payload and making radiation measurements at the surface and at 2 m (6.5 ft) from the surface. Thermal testing before first use is also required and is performed with the actual payload, verifying surface temperatures within design predictions. Should shielding or thermal tests exceed the acceptance levels for a particular cask, the acceptable loading for that cask will be reduced to levels that will meet the thermal and radiological requirements.

As a final assurance of confinement integrity, a torque test is required for the lid closure bolts. This test verifies that the preload on the lid closure bolts at the specified torque is correct and assures bolt loadings no greater than those specified in the SARP (HNF-SD-TP-SARP-024).

After each use, inspection for "wear and tear" and the usual cleaning of components is performed. Regular maintenance requires the BUSS cask lid and port seals to be replaced after each shipment. A periodic test and inspection schedule is provided to assure that the cask body, impact limiters, trunnions, and other components meet original requirements over the life of the packaging. However, quantitative acceptance criteria and repair procedures are not specified and the condition specified in Chapter 7 of this SER is included in the Certificate of Compliance to address the preceding deficiencies in the SARP (HNF-SD-TP-SARP-024).

The staff concludes that the acceptance tests and maintenance program requirements presented in Chapter 8 of the Revision. 0 of the SARP (HNF-SD-TP-SARP-024), together with the requirements specified in Chapter 7 of this SER and included in the Certificate of Compliance, are acceptable and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71, 49 CFR Part 173, and DOE Order 460.1A have been met.

CHAPTER 9 - QUALITY ASSURANCE

The requirements for a Quality Assurance (QA) Plan presented in the QA chapter 9 of the SARP (HNF-SD-TP-SARP-024) have been reviewed and found to meet the QA requirements of 10 CFR Part 71, Subpart H. These QA requirements provide sufficient control over all items and quality-affecting activities that are important-to-safety as applied to the design, fabrication, assembly, inspection, testing, operation, maintenance, and repair of the BUSS Cask. The QA requirements are based on a graded approach as described in 10 CFR 71.101. The graded approach in the QA Chapter includes an important-to-safety Q-list for each item and is graded based on the design function of the item relative to the safety and performance requirements for the complete shipping package. The quality assurance levels for each component are listed in Volume II, pages D-3 through D-9. The Q-list uses three QA levels with associated definitions for each. The QA level of each important-to-safety item is based on specific criteria. The QA requirements assure that the BUSS cask is designed, fabricated, and tested in accordance with the drawings identified in the SARP (HNF-SD-TP-SARP-024). In addition, the QA chapter requires the user to invoke the same level of QA requirements for the use, maintenance, and repair of the packaging as is required for the procurement, fabrication, and acceptance testing of the original packaging. The QA levels for important-to-safety items and activities are based on the following definitions:

1. QA Level 1 (Critical)

   Critical Level 1 items are structures, components, and systems whose failure or malfunction could directly result in an unacceptable condition of shielding.

2. QA Level 2 (Major)

   Major Level 2 items are structures, components, and systems whose failure or malfunction could indirectly result in an unacceptable condition of shielding. An unsafe condition of shielding could result only if the failure or malfunction of a QA Level 2 item occurred in conjunction with the failure or malfunction of other items in the same QA level.

3. QA Level 3 (Minor)

Minor Level 3 items are structures, components, and systems whose failure or malfunction would not reduce packaging effectiveness and would not result in an unacceptable condition of shielding regardless of other failures or malfunctions of items in the same QA level.

After determining the applicable QA level, the appropriate level of QA effort for design, procurement, fabrication, testing, operations, maintenance, modification, and repair activities is determined from the 18 QA elements identified in 10 CFR Part 71, Subpart H. The 18 elements identified in the SARP (HNF-SD-TP-SARP-024) are organization; quality assurance program; design control; procurement document control; instructions, procedures, and drawings; document control; control of purchased material, equipment, and services; identification and control of material, parts, and components; control of special processes; inspection control; test control; control of measuring and test equipment; handling, shipping, and storage control; inspection, test, and operating status; control of nonconforming materials, parts, or components; corrective action; QA records; and QA audits. Table 9.3-5 provides a list of permanent (lifetime of packaging) and nonpermanent records; however, Table 9.3-5 fails to define permanent records as lifetime of the cask plus three years in accordance with 10 CFR 71.135.

The QA chapter of the SARP (HNF-SD-TP-SARP-024) includes independent verification of operational activities and inspection points considered to be critical in satisfying the regulatory requirements for shielding as identified in 10 CFR Part 71. Verification of critical activities is contained in Section 9.3.10.2 and Tables 9.3-1, 9.3–2, 9.3-3, and 9.3-4 of the SARP.

The staff concludes that the QA requirements presented in the QA chapter of the SARP (HNF-SD-TP-SARP-024) are in conformance with the established criteria in Subpart H of 10 CFR Part 71, 49 CFR Part 173, and DOE Order 460.1A provided that the requirement to retain permanent records for the lifetime of the cask plus three years is included as a requirement in the CoC.

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